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Request for grant of a patent

(See the notes on the back of this form. You can also get an explanatory leaflet from the Patent Office to help you fill in this form)

1. Your reference — JTS/P08253GB — 01 MAY 1998

2. Patent application number *(The Patent Office will fill in this part)* — 9809482.4

3. Full name, address and postcode of the or of each applicant *(underline all surnames)*

   VLSI Vision Limited
   Aviation House
   31 Pinkhill
   Edinburgh EH12 7BF

   Patents ADP number *(if you know it)*

   If the applicant is a corporate body, give the country/state of its incorporation — Scotland, UK — [illegible]

4. Title of the invention — IMAGE CAPTURE CONTROL

5. Name of your agent *(if you have one)* — CRUIKSHANK & FAIRWEATHER

   "Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*

   19 Royal Exchange Square
   Glasgow G1 3AE
   United Kingdom

   Patents ADP number *(if you know it)* — 547002 ✓

6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and *(if you know it)* the or each application number

Country	Priority application number *(if you know it)*	Date of filing *(day / month / year)*

7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application

Number of earlier application	Date of filing *(day / month / year)*

8. Is a statement of inventorship and of right to grant of a patent required in support of this request? *(Answer 'Yes' if:*
   a) any applicant named in part 3 is not an inventor, or
   b) there is an inventor who is not named as an applicant, or
   c) any named applicant is a corporate body.
   See note (d)) — Yes

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9. Enter the number of sheets for any of the following items you are filing with this form. Do not count copies of the same document

Continuation sheets of this form	—
Description	5
Claim(s)	—
Abstract	— to
Drawing(s)	7

10. If you are also filing any of the following, state how many against each item.

Priority documents	—
Translations of priority documents	—
Statement of inventorship and right to grant of a patent *(Patents Form 7/77)*	—
Request for preliminary examination and search *(Patents Form 9/77)*	—
Request for substantive examination *(Patents Form 10/77)*	—
Any other documents *(please specify)*	—

11. I/We request the grant of a patent on the basis of this application.

Signature Date 1.5.98

(Agents)

12. Name and daytime telephone number of person to contact in the United Kingdom 0131 228 2992

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Notes

a) If you need help to fill in this form or you have any questions, please contact the Patent Office on 0645 500505.

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IMAGE CAPTURE CONTROL

This patent application relates to techniques for acquiring images from a solid-state imager when exposure to the scene is controlled by either an asynchronous lighting strobe. or by the asynchronous opening of a shutter. The techniques that we describe do not require an electronic connection between the strobe/shutter and the sensor in order to work, and are hence applicable for use in systems were there is a physical reason, or an electronic reason why this connection is not feasable.

Background

Solid state image sensors dominate electronic imaging applications such as CCTV, video cameras and camcorders, scanners, and are the basis of newly developed markets such as PC-cameras for videoconferancing, medical vision, machine vision and Digital Stills Cameras.

One popular form of image sensor is the Charge Coupled Device (CCD), whilst sensors built entirely within standard CMOS processes are also gaining currency. Both have their relative merits when applied to these techniques.

In some systems it is desirable to seperate the operation of the sensor from the exposure mechanism. One such appliaction is Electronic Film, for use in conventional Silver Halide Cameras such as 35mm SLR (Single Lens Reflex). Here the solid state sensor replaces the chemical film within the camera, and as with chemical film the exposure is controlled by the shutter of the camera. In order that such an Electronic Film can work without user modification of the camera to access the shutter control signal, or with older non-electronic cameras, it is necessary for the sensor to auto-detect that it has been exposed. This system must offer a high probability of succesful detection , and be scene independant, working under the widest possible range of camera exposures, and additional operating conditions such as flash and fill-in flash.

Another application is in medical vision and in machine vision, where exposure/illumination occurs through an illumination strobe, and there are physical or electronic reasons why a syn-

chronisation pulse between the light source and the sensor can not occur. For example it may be necessary to isolate the light source from the detector for reasons of safety, as in an X-ray system.

Summary of invention

Figure 1 shows a general system incorporating a solid state image sensor with a shutter (electronic, mechanical, or electromechanical), a lighting stobe, and a detector. The shutter and/or the lighting stobe provide means of asynchronous stimulation of the image sensor. The classic approach to the problem would be try to detect the asynchronous event and to then subsequently instigate an exposure and acquisition sequence for the image sensor. The problem with this approach is that it puts design pressure on acheiving an asynchronous event detector that is sufficiently fast and reliable, that the interaction between activating the image sensor and the asynchronous stimulus does not corrupt the effective exposure. Fig 2a shows a timing diagram of an image acquisition sequence where the detector triggers the release from reset of the array, putting it into integration, it is then read when the stimuli has gone away. In this example the solid state image sensor and the detector see the stimuli simultaneously, as in the case of a lighting strobe. As can be seen the time for the detector to trigger, Td, reduces the effective amount of the stimuli, Ts, to an amount Te, that is approximately equal to :-

$Te = Ts - Td$

If there is a spatial distance between the detector and the image plane of the solid state sensor with respect to the stimuli, as in the case of a blade shutter in an SLR camera then the Td can result in a gradiant of exposure across the array. Fig 2b shows an example of what would happen to an array if the detector was located to the left hand side of the array, and the shutter was opening from the right hand side of the array. If Tsh1 is the time the shutter takes to cross the array and Tsh2 is the subsequent time for the shutter to pass from the array to the detector, then as the diagram shows the two sides of the array see different effective stimuli, Te1 and Te2, as defined by :-

$Te1 = Ts - Td - Tsh1 - Tsh2$

$Te2 = Ts - Td - Tsh2$

This problem can be reduced by using detectors on the side of the shutter that opens first, but still if the time to detect Td is greater than the time to reach the array Tsh2, then there will be a gradiant of exposures across the array. The effective stimuli will be soemwhere between the following values :-

$(Ts-Tsh2) < Te < (Ts-Td)$, were $Tsh2 > Td$

dependant on the position in the array. This is clearly undesirable

We describe a more radical approach to the problem that greatly increases the probability of succesful detection of the asynchronous event with no degredation of the stimuli. This approach can be briefly described below:-

a) The image sensor is regularly reset, at a repetition rate of Tr, this is known as the detect period. In this period between the resets the image sensor is integrating any incident light.
b) If during a given detect period the detector has fired, indicating that there has been some asynchronous stimuli, of duration Ts,, then the next reset pulse is inhibited, and the sensor enters it's continued integration period .
c) In the continued integration period, Tc, the integration of the array is continued to beyond the extent of the longest asynchronous stimulation, Ts(max). This may either be a fixed time or a time based on a trigger by a detector that the stimuli has gone away. The sensor now enters the readout period.
d) In the array readout period, Ta, the array is readout, and can then go back to the detect period to await the next asynchronous event.

We have called this approach the 'inhibited reset' approach. Fig 3a shows the basic timing for an asynchronous event that occurs totally inside the detect period, and Fig 3b an event that would straddle the reset periods, but for the 'inhibited reset'. The time for the detector to fire is Td, and the probability of aqcuiring the asynchronous event without any corruption is :-

Probability of success = (Tr-Td)/Tr and normally Tr >> Td

Note in both cases the effective exposure, Te3, seen by all of the array and the detector is the full time of the stimuli,

Te3 = Ts

Fig 3c shows the case were the stimuli occurs <Td away from where the reset would occur, in this case the reset would NOT be inhibited in time, but it is important to note that this is no worse than the classic approach described earlier.
In this case the effective exposure, Te4, is :-

Te4 = Ts - Td

The detector in both the classic approach and the 'inhibited reset' approach need not be a direct detector, ie another optical sensor that is also looking for the same type of optical stimuli, although this by far the most popular approach. An examples of indirect detectors, are a vibration or a sound transducer for detecting the movement of a physical shutter.

In the case of the optical detector, it is often co-located with the image sensor, but it is not possible to put it in the same focal plane as the image sensor. This can give problems in a lensed system, as the detector may not be focused on a part of the scene with sufficient luminance to trigger it.

However, with our 'Inhibited reset approach' it is possible to use a sub-sampled portion of the

array, in such a way that the image array itself can act as the detector of the asynchronous stimuli. This is because the array is already integrating during it's detect period. therefore by reading it before the decision to inhibit reset or not, you have a sample of the light that has been integrated by the array. By comparing these values with the values obtained when there has been no stimuli, we have a measure of the change. If this change is greater than a user defined threshold, then you can say that an asynchronous stimuli has occured. The choice of this threshold, relative to the lowest energy stimuli it is desired to detect determines the effective time to detect, Td in the following way. Fig 4. If Ts is the longest stimuli to cause saturation of the image sensor, Tsa is the time to read the sub-array, and Pt is the percentage of saturation that is required to trigger a threshold of detection, then the effective Td is

$$Td = (Ts * Pt) + Tsa$$

The major advantage of this approach is that the array itself is acting as the detector and is therefore in the focal plane of the focused image. Spatially distributing the sub-sample, greatly increases the probability that some of the pixels of the sub-sample are in areas with sufficient luminance.

It is of course possible to use our described 'Inhibited reset approach' with a plurality of detectors and sub-sampled arrays, to determine if anasynchronous event has occured.

Claims

1) A means of operating a solid state image sensor for the acquisition of an image generated by an asynchronous stimuli, where said image sensor is operated in conjunction with at least one detectors, said detectors, detect the the said asynchronous stimuli by either direct or indirect means, Said image sensor is regularly put into integration by releasing the array from it's reset state at a period Tr. the state of said detectors prior to each reset determining whether that reset should be inhibited to prevent corruption of said stimuli.

2) The use of a solid state image sensor for the acquisition of an image generated by an asynchronous stimuli, were said image sensor is regularly being put into integration by releasing the array from it's reset state at a period Tr, where some portion of the array is read prior to each reset and the values of this read determine whether the subsequent reset should be inhibited to prevent corruption of said stimuli.

As used herein the expression "asynchronous stimulus" means a stimulus the timing of whose occurrence is not known in advance and which stimulus is associated with the presentation of an image to be captured to the solid state image sensor. As discussed herein various kinds of solid state image sensors known in the art may be used in the present invention, including CCD sensors as well as sensors such as those disclosed in our earlier patent publication WO91/04633, in which, following a resetting of the sensing cells, charge is built up on the sensing cells in response to incident radiation impinging thereon and the built up charge subsequently converted into a voltage signal during an integration period, and this cycle repeated upon the next resetting of the sensing cells. In relation to the "continued integration period" it will be appreciated that this could be an extended period corresponding in effect to the inhibition of more than one reset pulse i.e. a series of successive reset pulses.

The present invention provides in one aspect an image capture control device suitable for use with a solid state image sensor for the acquisition of an image presented to the sensor in response to an asynchronous stimulus, said device comprising at least one detector means formed and arranged for detecting, in use of the device, directly or indirectly, a said asynchronous stimulus, and reset inhibition control signal output means formed and arranged for generating a reset inhibition control signal in response to detection of said asynchronous stimulus and supplying it, directly or indirectly, in use of the device, to a reset signal generating means operatively coupled to said solid state image sensor, so as to inhibit the application of at least one subsequent reset signal to the sensing cells.

In a further aspect the present invention provides a camera having a solid state image sensor, wherein is provided an image capture control device of the present invention.

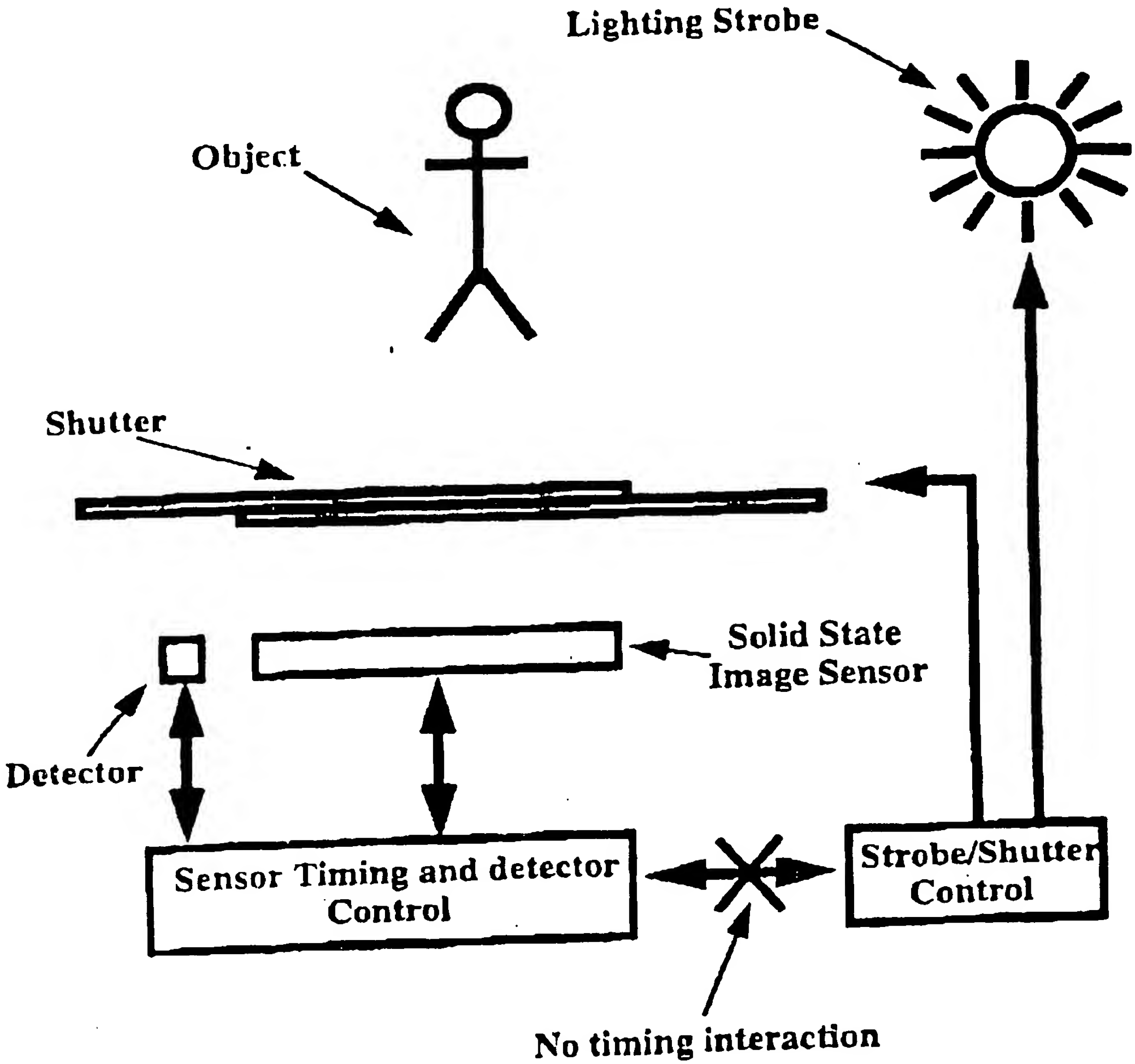


Figure 1:

Solid State Sensor in a system with an asynchronous stimuli

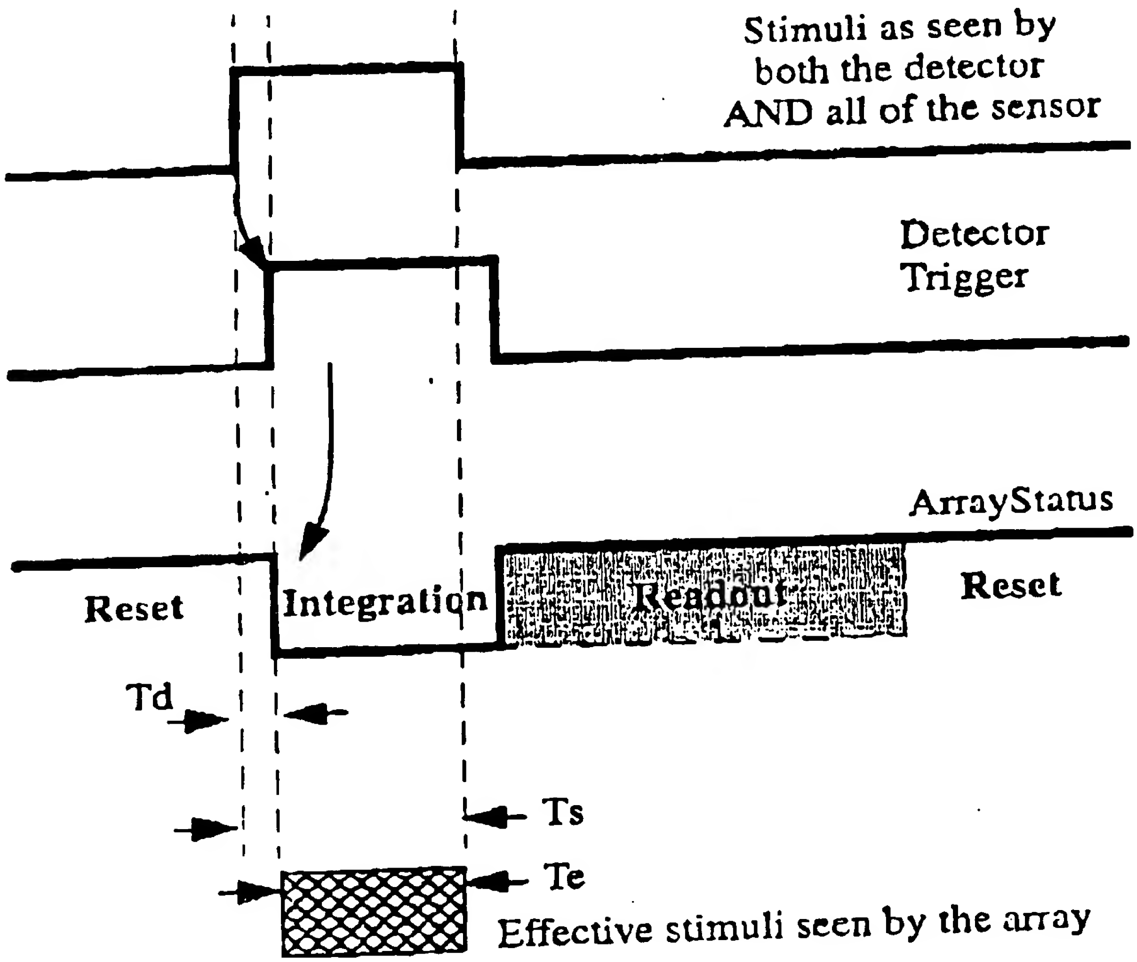

Stimuli as seen by
both the detector
AND all of the sensor
Detector
Trigger
ArrayStatus
Reset
Integration
Readout
Reset
Td
Ts
Te
Effective stimuli seen by the array

Figure 2a

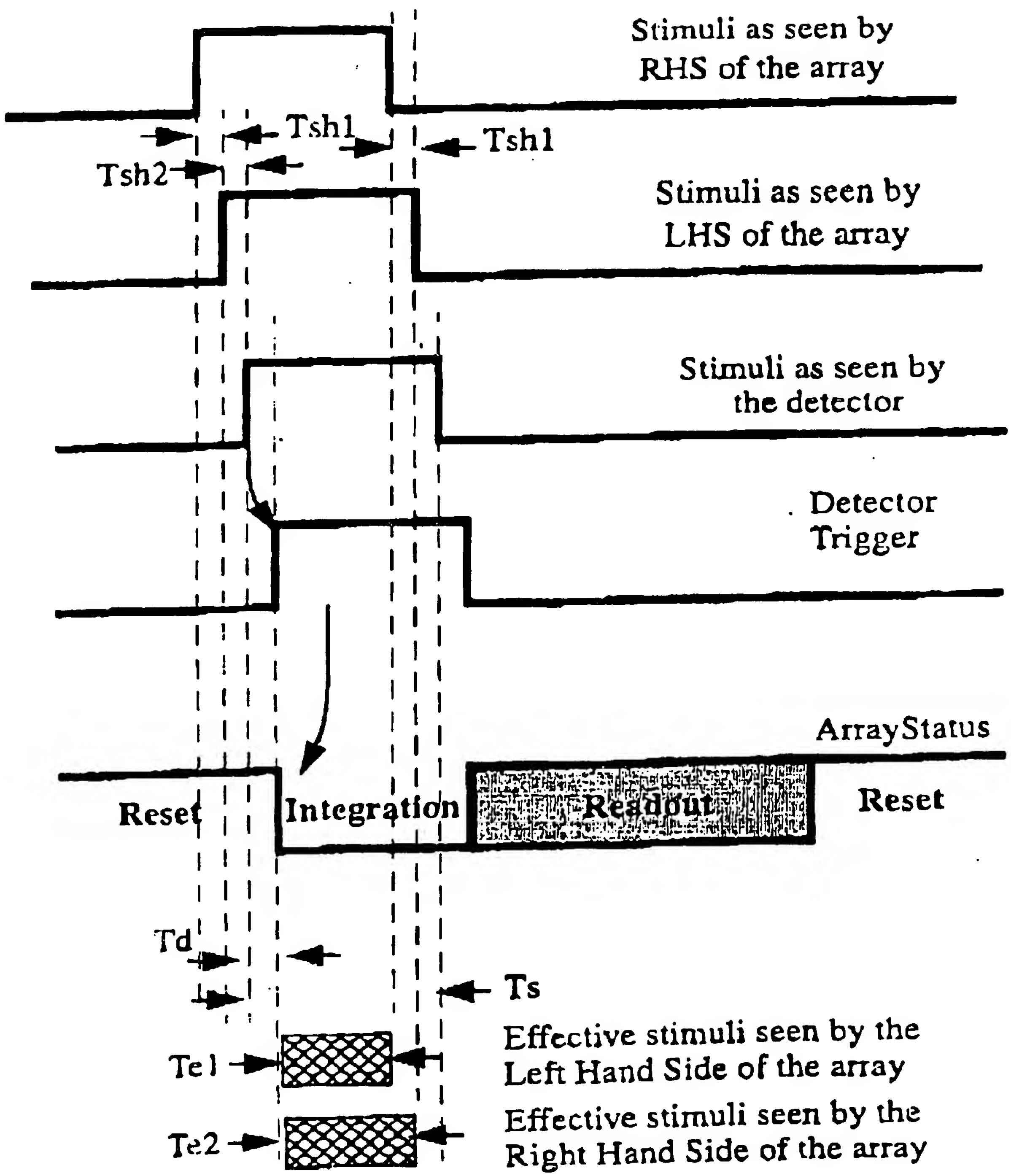

Stimuli as seen by
RHS of the array
Tsh1
Tsh1
Tsh2
Stimuli as seen by
LHS of the array
Stimuli as seen by
the detector
Detector
Trigger
ArrayStatus
Reset
Integration
Readout
Reset
Td
Ts
Te1
Effective stimuli seen by the
Left Hand Side of the array
Te2
Effective stimuli seen by the
Right Hand Side of the array

Figure 2b

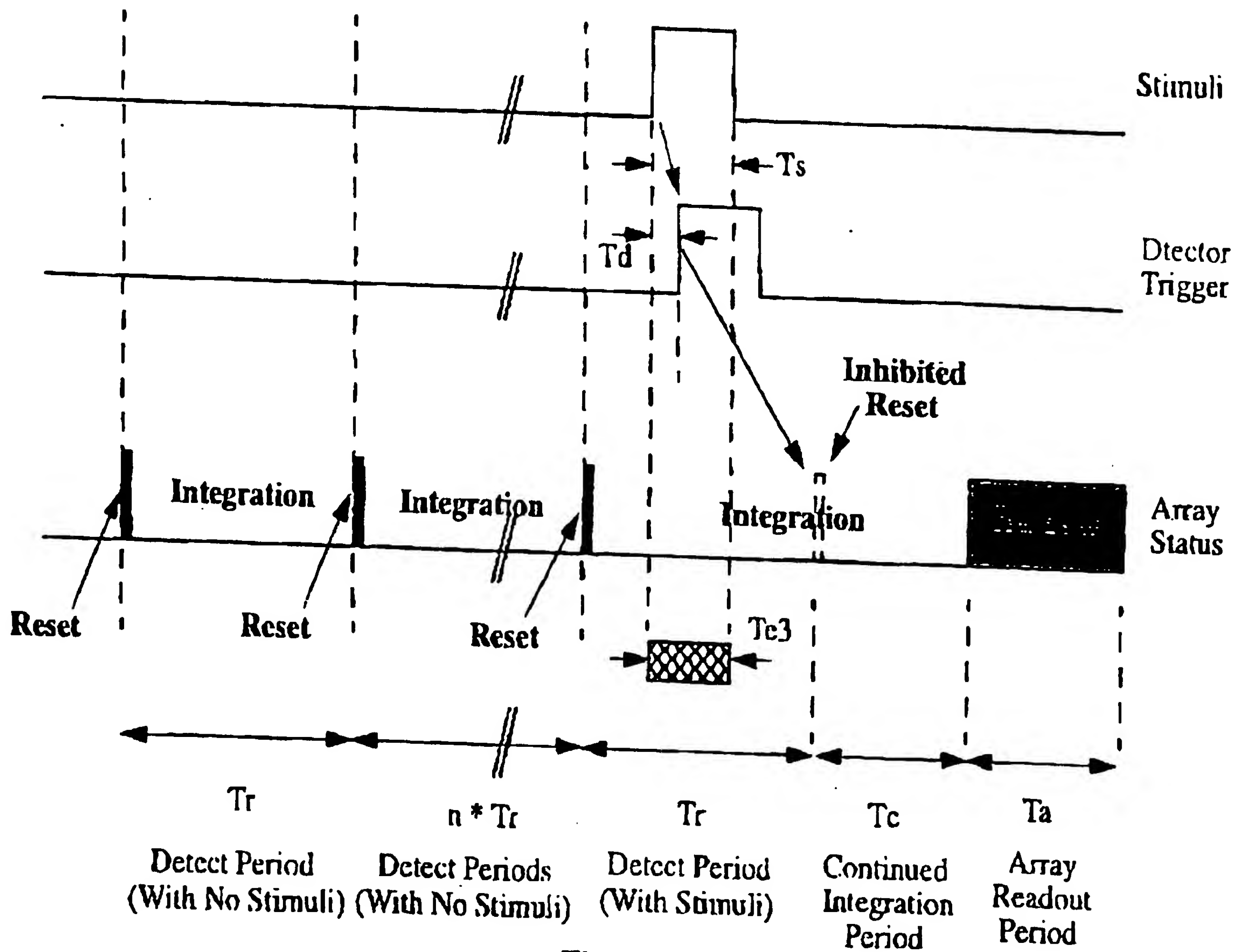
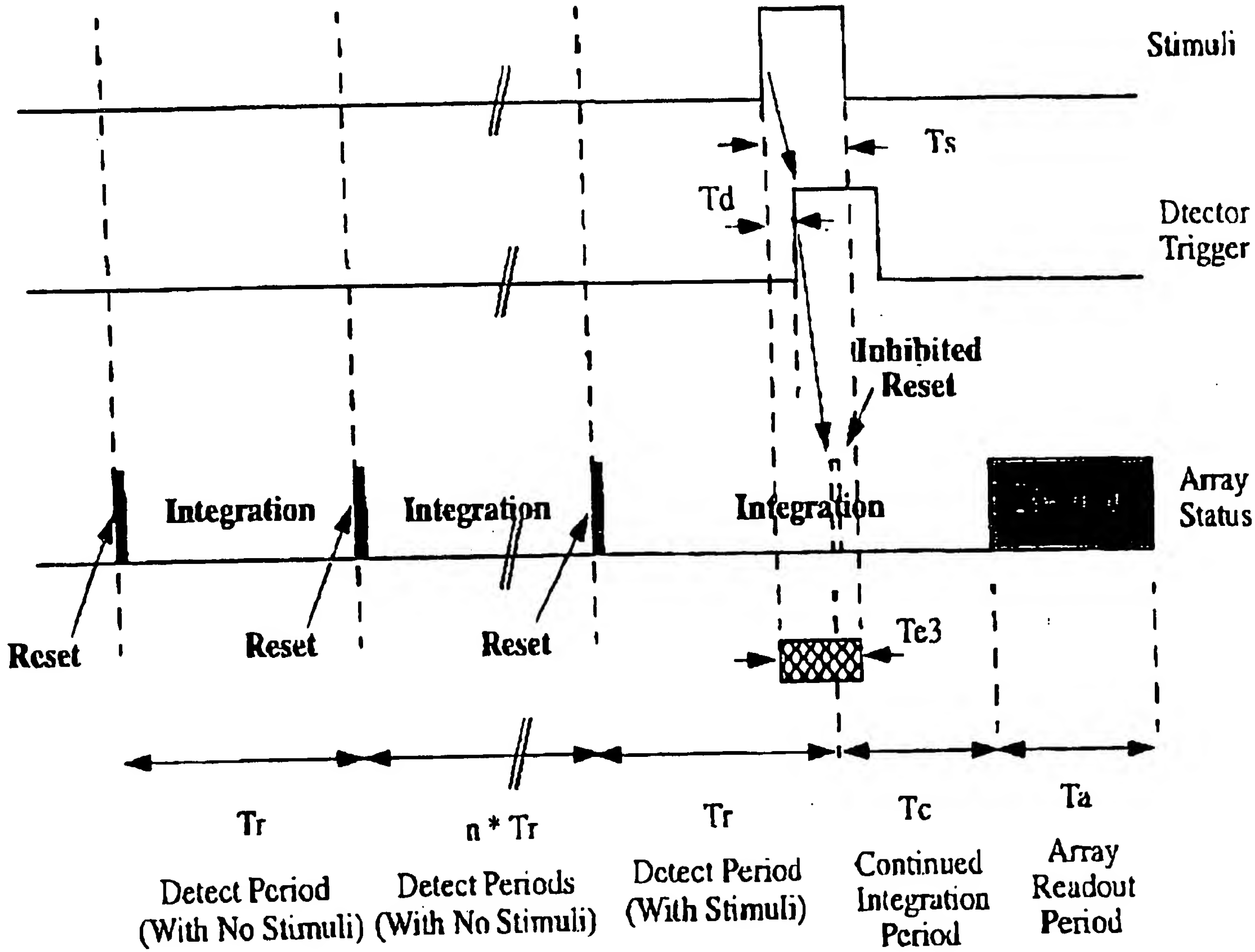

Stimuli
Dtector Trigger
Array Status
Ts
Td
Inhibited Reset
Integration
Integration
Integration
Reset
Reset
Reset
Te3
Tr
Detect Period (With No Stimuli)
n * Tr
Detect Periods (With No Stimuli)
Tr
Detect Period (With Stimuli)
Tc
Continued Integration Period
Ta
Array Readout Period

Figure 3a



Stimuli
Dtector Trigger
Array Status
Ts
Td
Unbibited Reset
n
Integration
Integration
Integration
Reset
Reset
Reset
Te3
Tr
Detect Period (With No Stimuli)
n * Tr
Detect Periods (With No Stimuli)
Tr
Detect Period (With Stimuli)
Tc
Continued Integration Period
Ta
Array Readout Period

Figure 3b

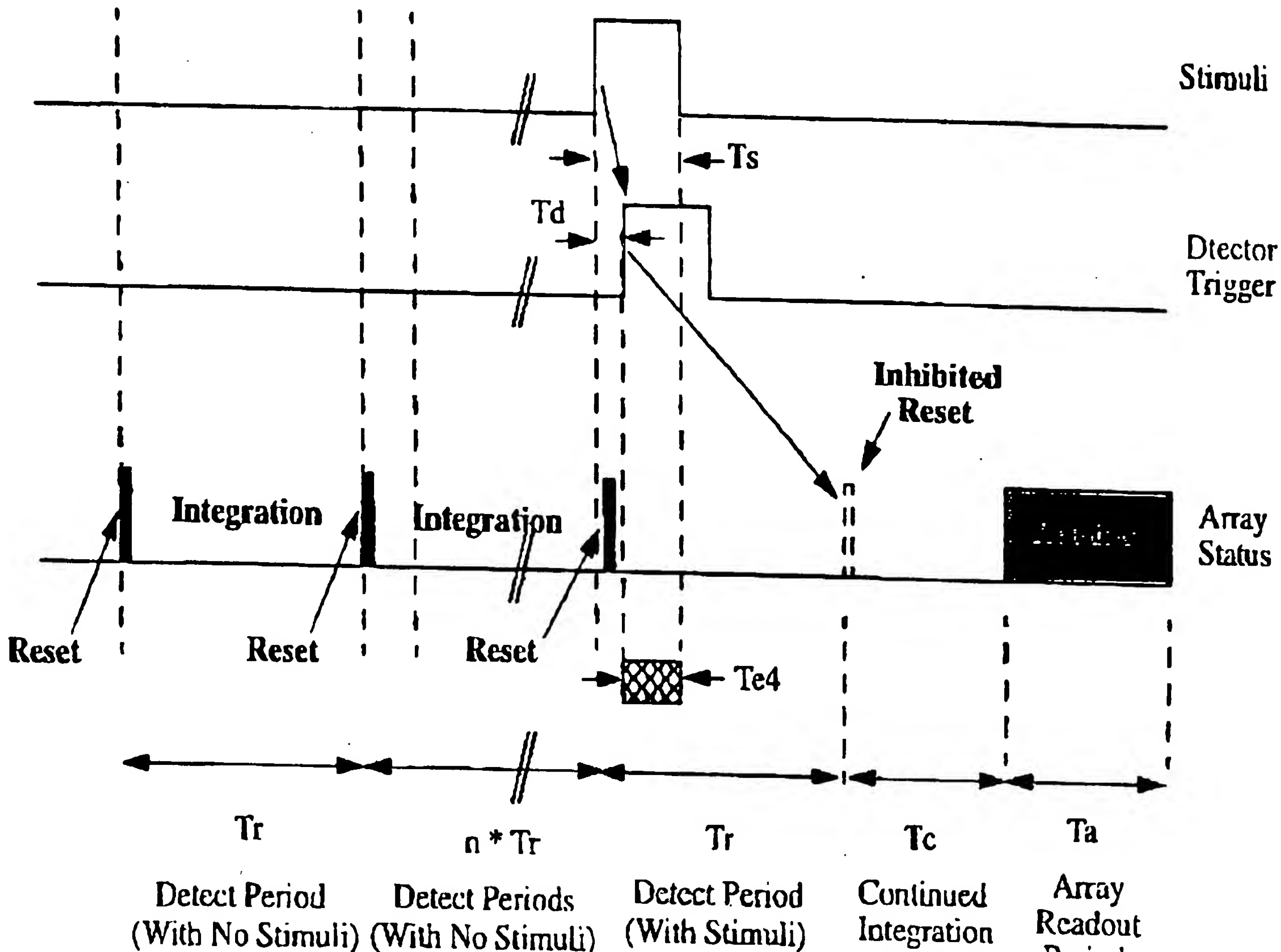

Stimuli
Ts
Td
Dtector
Trigger
Inhibited
Reset
Integration
Integration
Array
Status
Reset
Reset
Reset
Te4
Tr
n * Tr
Tr
Tc
Ta
Detect Period
(With No Stimuli)
Detect Periods
(With No Stimuli)
Detect Period
(With Stimuli)
Continued
Integration
Period
Array
Readout
Period

Figure 3c

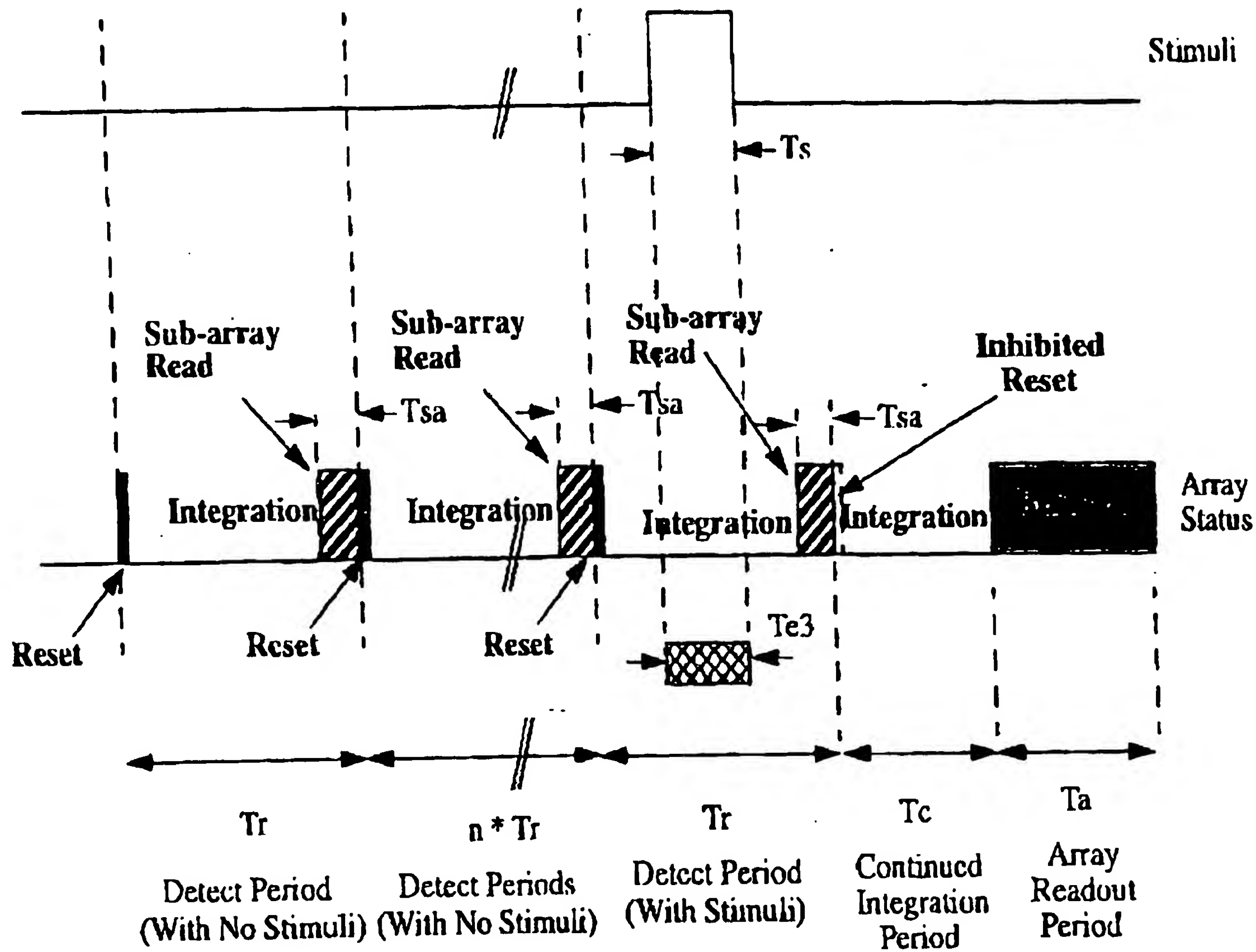

Stimuli
Ts
Sub-array Read
Sub-array Read
Sub-array Read
Tsa
Tsa
Tsa
Inhibited Reset
Integration
Integration
Integration
Integration
Array Status
Reset
Reset
Reset
Te3
Tr
n * Tr
Tr
Tc
Ta
Detect Period (With No Stimuli)
Detect Periods (With No Stimuli)
Detect Period (With Stimuli)
Continued Integration Period
Array Readout Period

Figure 4

PC7/96 99/01365

CRUIKSHANK & FAIRWEATHER.

30/4/99